Chapter 15

Writing the results and discussion

> Huge volumes of data may be compelling at first glance, but without an interpretive structure they are meaningless.
>
> Tom Boellstorff
> *Ethnography and Virtual Worlds: A Handbook of Method, 2012*

Results and Discussions are the main thrust of the research report or thesis—they present the findings of the study and the author's discussion or interpretation of these findings. In the *Results and Discussion* section or chapter, you present results that answer your research questions or address your objectives or hypotheses. You may need to translate the results from figures in a table, figure or equation to descriptions or statements about their significance or relationships in your study's context. Also, you may need to refer to information related to your methodology and/or the technical/theoretical background of your methods and materials.

COMPONENTS OF RESULTS AND DISCUSSION

A comprehensive breakdown of the components of *Results and Discussion* is shown in Writing Guidelines 15.1 based on a synthesis of findings by Swales and Feak (2012), Peacock (2002) and our analysis of engineering reports and theses.

Component 1 includes three steps, namely, a statement of background information (Step A), a restatement of methodological information (Step B) and a restatement of research questions/hypotheses (Step C). According to Swales (1990), the indication of background information (Step A) '…is employed by authors when they wish to strengthen their discussion by recapitulating main points, by highlighting theoretical information, or by reminding the reader of technical information'. The restatement of methodological-related information (Step B) is specific to a result which the author presents in writing. It is typical in some engineering texts to contextualise findings with background or methodological information even though relevant methodological information is already

Writing Guideline 15.1 Components of *Results and Discussion*

Results

Component 1: Present meta-textual information

A. State background information
B. Restate methodological information
C. Restate research questions/hypotheses

Component 2: Present finding

A. Direct readers' attention to table or figure
B. Highlight finding

Discussion

Component 3: Interpret findings

A. Explanation of finding (suggest reasons; argue for a cause–effect relationship)
B. Make a generalisation based on finding
C. Compare with previous findings (and show consistency or inconsistency, with explanation)
D. Support from theories
E. Make an inference (with sufficient support from findings and relevant literature)

presented in the *Materials and Methods* section. Step C is a restatement of the research question/hypothesis related to a finding. This step is often found in undergraduate and postgraduate reports or theses but usually not found in research articles.

Step C in Component 1 is followed by Component 2, presentation of findings. You should present only findings that address your research questions/hypotheses. If your data analyses reveal surprising findings not related to your research questions/hypotheses, you may want to add research questions to your *Introduction*. However, you should first discuss the ideas with your supervisor. The presentation of findings consists of the following steps. Step A is necessary to direct readers' attention if there are tables or figures which need to be referred to in the text. For example, you can use phrases such as 'with reference to Table 2', 'see Figure 5.3' or simply state the figure or table number in parenthesis, such as '(Table 3.4)' at the end of a relevant sentence. Step B is required to highlight an important finding or result, with technical or mathematical explanation. This explanation is limited to empirical observations. Explanations of causality (relationship of cause and effect) are indicated in Step A of Component 3 in the typical content structure.

Component 3 is the start of the discussion section/chapter which details your comments or interpretations of your results. There are five types of comments (A–E) to include as discussion of findings. Type A comments give or suggest reasons or argue for a causality which can be indicated by words such as *cause*, *attributed to*, *contributed and led to*. Type B comments make a generalisation or deduction based on findings, which can be indicated by words such as *generally, overall, typical of and usually*. Type C comments compare finding/s with previous findings to show consistency or inconsistency, which are marked with in-text citations (see *Chapter 18—Referencing*) and can be indicated by words such as *in agreement with, dissimilar to and corroborate with*. Type D comments state explanations of findings based on existing theories, which are marked with in-text citations if theories are found in scholarly works and can be indicated by words such as, *agree with, supported by, consistent with and substantiated by*. Regarding Types C and D comments, and the cited studies should already be discussed in the *Literature Review* so that you can refer to them in your discussion of results. Type E comments contain inferences which could include explanations or generalisations that are logically sound but lack empirical support. Inferences can be indicated by hedges (words that expresses uncertainty) such as *probably, hypothetically, subject to further empirical investigations and a possibility*.

Note: Not all the various types of comments need to be present in a *Results and Discussion* section.

A sample content analysis of a sample *Results and Discussion* section is shown in Writing Guidelines 15.2.

Writing Guidelines 15.2 Content analysis of a sample *Results and Discussion* section

Abstracted from Wijaya and Leong (2014)

Comparison of shrinkage curve equations for soft soils

Six soft soils (NSF clay, kaolin clay, Kasaoka clay, Kurita clay and two marine clays subjected to different loading stages) will be evaluated in this paper using three different shrinkage curve equations which are Braudeau et al. (1999) equation, Fredlund et al. (2002) equation and Leong and Wijaya (2015) equation **(1B)**[a].

All of the soft soils investigated in this paper only have two linear segments which is the most common type of shrinkage curve **(1A)**. Therefore, the three shrinkage curve equations which are able to model more than two linear segments shrinkage curve were simplified to model two linear segments shrinkage curve only **(1B)**. The NSF clay and kaolin are intended for industrial use, Kasaoka clay was made from crushed mudstone taken from an area near Kasaoka city while Kurita clay is a natural soil sampled from Nagano city (Umezaki and Kawamura 2013) **(1A)**. The two marine clay soils were from Termunten on the northern coastal area of the Netherlands (Kim et al. 1992) **(1A)**. The two marine clays were under different loading stages and therefore have different initial gravimetric water contents **(1A)**.

The Braudeau et al. (1999) equation (BEA model) was shown to be versatile in modelling a shrinkage curve as it uses explicit parameters (water content and void ratio at the point of convergence between each linear segments) and has high accuracy (Cornelis et al. 2006a; Leong and Wijaya 2015) **(1A)**. The equation divides the shrinkage curve into linear parts and a non-linear part **(1A)**. The linear parts are used to represent the zero shrinkage line and loading line while the non-linear part is used to represent the residual shrinkage phase **(1A)**. It is expected that the void ratio at the shrinkage limit e_{SL} is the same as the minimum void ratio e_{min} as the shrinkage curve has reached the zero shrinkage phase and

(*Continued*)

Writing Guidelines 15.2 (*Continued*) Content analysis of a sample *Results and Discussion* section

further reduction in water content will not cause additional shrinkage **(1A)**. Braudeau et al. (1999) equation for a two linear segment shrinkage curve is given as:

$$e = \begin{cases} e_{min};\ w \le SL \\ e_{SL} + (e_{AE} - e_{SL})\dfrac{f}{\exp(1) - 2};\ SL < w \le w_{AE} \\ e_s + (e_{AE} - e_s)\dfrac{w - w_{AE}}{w_s - w_{AE}};\ w > w_{AE} \end{cases} \tag{1}$$

and,

$$f = \exp\left(\frac{w - SL}{w_{AE} - SL}\right) - \left(\frac{w - w_{SL}}{w_{AE} - SL}\right) - 1 \tag{2}$$

where e is the void ratio, e_{AE} is the void ratio at the air entry point and e_s is the void ratio at full saturation **(1A)**.

Fredlund et al. (2002) equation (FEA model) was proposed for use in geotechnical engineering to describe shrinkage curves with two linear segments **(1A)**. However, it has not been compared with other shrinkage curve equations **(1A)**. The equation is given as:

$$e(w) = e_{min}\left(\frac{w^C}{SL'^C} + 1\right)^{1/C} \tag{3}$$

where SL' is the apparent shrinkage limit which corresponds to the water content at the intersection of the loading line and the zero shrinkage line and C is a model parameter which requires curve fitting to obtain its value **(1A)**. Typical C values for different types of soils are given in Fredlund et al. (2002) **(1A)**.

Leong and Wijaya (2015) equation (LW model) was proposed to provide a single continuous equation with explicit parameters to model a shrinkage curve with more than two linear segments **(1A)**. The simplified form of Leong and Wijaya (2015) equation for a two linear segment shrinkage curve is given as:

$$e(w) = e_{min} + \frac{G_S}{2S_0}\left\langle w + \frac{1}{k}\ln\left\{\frac{\cosh\left[k(w - SL')\right]}{\cosh(k..SL')}\right\}\right\rangle \tag{4}$$

where G_S is the specific gravity, S_0 is the initial degree of saturation and k is a parameter which is related to the curvature **(1A)**. Parameter k can be obtained from SL and AE by the following relationship:

$$k = \frac{2}{AE - SL} \tag{5}$$

For the above-mentioned three shrinkage curve equations, only the C parameter in the FEA model needs to be curve-fitted (implicit-parameter) while the BEA model and LW models use explicit parameters **(1A)**. Therefore, in the comparison the C parameter in the FEA model was curve-fitted while the other parameters in the FEA model used were the same parameters as those used in the BEA and the LW models (1B). The results are shown in Figures 2 and 3 with the coefficients of determination, R^2. The R^2 for each model is indicated by the subscript (2A). The results show that the three equations give very high R^2 values **(2B)**. Overall, the LW model performed the best,

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Writing Guidelines 15.2 (Continued) Content analysis of a sample *Results and Discussion* section

followed by the FEA model and then the BEA model **(3B)**. However, in Figure 3b, the FEA model gives a shrinkage curve that lies on the left of the loading line although it has a high R^2 value **(2B)**. Another observation in Figure 3b concerns the BEA model **(2A)**. The shrinkage curve for the BEA model crosses the loading line which is theoretically not plausible **(2B)**. This is because the non-linear part of the BEA model does not consider the existence of the loading line **(3A)**.

[a] Bracketed term at the end of each sentence indicates a step, for example, **(1B)** indicates step B of Component 1, **(2B)** indicates step B of Component 2 and so on as shown in Writing Guidelines 15.1.

ORGANISING RESULTS AND DISCUSSION

There are two ways of organising your *Results and Discussion*. You can present all your findings together and then follow with a discussion of the findings either within the same section or chapter or in separate sections or chapters. This presentation format is called the sequential pattern. This pattern can be represented as follows:

Sequential pattern: $R1 + R2 + R3 + R4 + D$

[R = Results; D = Discussion]

Of course, this pattern can be extended if you have more than four findings or results to report.

The second way of ordering your results and discussions is to present a finding and then discuss or comment on it before presenting the next finding followed by discussion. This presentation format is called the alternating pattern and can be represented as follows:

Alternating pattern: $R1 + D + R2 + D + R3 + D + R4 + D$

[R = Results; D = Discussion]

The alternating pattern is best if you have many different results and you have specific discussions on each of these results. The sequential pattern is better when you have several different results to which one discussion can apply.

COMMON LOGICAL PITFALLS IN RESULTS AND DISCUSSION

Some common problems that may occur in the writing of *Results and Discussion* sections, particularly when you comment on a finding or findings, are as follows:

False analogy—Divergent items are compared and equated as evidence.
Example: Selling synthetic meat* to people is like selling poisoned food to them. They will be poisoned, fall ill and die.

* Synthetic meat is also known as test-tube meat, in vitro meat, victimless meat, cultured meat, tubesteak, cruelty-free meat, shmeat and artificial meat.

Post hoc or false cause ('after this, therefore because of this')—When an event follows another, it is assumed that the former caused the latter.

Example: An increase in artificial meat sales last year was followed by an increase in heart disease, atherosclerosis and asthmatic cases this year. Therefore, we should ban artificial meat because they cause heart disease.

Slippery slope—Slippery slope is a prediction of a drastic snowballing effect without substantial evidence.

Example: The unabated use of artificial meat will lead to a scarcity of natural food, followed by the collapse of farms globally and then a world economic depression.

False dilemma ('either/or')—It is insisted falsely that one or another of two alternatives must be chosen though there may be many other positions besides the two.

Example: We are faced with a grave situation—either we ban artificial meat and eliminate health problems or we promote artificial meat and be plagued with skyrocketing health problems.

SOME KEY LANGUAGE FEATURES OF RESULTS AND DISCUSSION

Verb tenses

Similar to the variation in verb tense in specific content components found in the *Introduction and Materials and Methods* sections, the verb tense varies in the *Results and Discussion* section. The simple past tense is used for Part 2 Component 1 (restating research questions) and Part 2 Component 2 (referring to tables or figures). In this case, tense is used interactively with the reader to reiterate the present study's research questions/hypotheses and direct or guide their attention. The simple past and past perfect tense are used to highlight findings (Part 2 Component 3). The tense is used for its temporal sense, to signal that data collection and analysis were conducted.

The simple present tense or present perfect tense is used in all the components of Part 3. Tense is used rhetorically to underlie the currency of the author's arguments and imply the author's support for the claims. See *Chapter 10—Grammar, punctuation and word usage guide* for an explanation of tenses.

Voice

Voice is a language-based impression of your identity as an author in your writing. In other words, voice refers to language features that highlight or downplay references to you as an author or other authors. Objective or impersonal language downplays your authorial identity. It should be recognised that your writing is subjective because it is written from your

Table 15.1 Impersonal language features

Impersonal language features	*Examples*
Passive voice	The results *were culled.*
Nominalisation	The *culling* of results…
Absence of self-mentions/author pronouns/ possessive adjectives	
'It is…that' clauses	*It is* established *tha*t culling of data…
'There is + noun' fronted sentences	*There is an assumption* that…
Attributive tags	*According to* Ong (2011),…
Personification or associations of inanimate things with verbs usually used with people	*The results demonstrate* that…

Table 15.2 Personal language features

Personal language features	*Examples*
Self-mentions/author pronouns/possessive adjectives	I; we; my; our; us
Engagement markers	As you can see; you will have noted that; consider whether

perspective. However, you can increase the acceptability of your subjective ideas by presenting them in impersonal language to imply that your ideas are largely unbiased. Most engineering writing employs objective language. Some impersonal language features and examples are detailed in Table 15.1.

Infrequently, engineering writing may involve subjective or personal language which highlights your authorial identity. There are two key subjective language features you can use. You may use self-mentions judiciously if you want to indicate ownership of your ideas, to imply your authority over a knowledge claim, or to hedge your claims as a personal opinion or inference. Also, you may want to use engagement markers to bring readers into the text as participants to highlight your anticipations of their objections or views, to direct them along a line of reasoning or to assume their solidarity with your views. Some personal language features and examples are detailed in Table 15.2.

Evaluative language

Evaluative language conveys personal attitudes, emotions, assessments and propositions from you as an author and/or other authors (Gray & Biber, 2012). According to Thompson and Hunston (2000), evaluative language or stance can express:

1. Positive–negative evaluations
2. Certainty–uncertainty in relation to a claim

Table 15.3 Evaluative language features and examples

Strategies	*Purpose*	*Examples*
Hedges	Indicate uncertainty—to withhold your full commitment to a statement	May; might; possibly; seemed to; appeared to
Boosters	Indicate certainty—to reveal your certainty about a statement	Clearly; definitely; without doubt
Attitude markers	Indicate positive or negative evaluations, or expectedness/ unexpectedness, or importance/ unimportance	Interestingly, surprisingly, unfortunately, importantly, significantly, scholarly, sound, problematic

3. Expectedness–unexpectedness of a claim
4. Importance–unimportance of a claim

Some key evaluative language features and examples are detailed in Table 15.3.

TIPS ON TYPING EQUATIONS

It is very likely that you will be typing equations in the *Results and Discussion* section. Equations are also commonly found in the *Literature Review* and *Materials and Methods* sections of engineering reports and theses. Many students are unaware that there is an equation editor in Microsoft Office suite. It is quite likely that you will need to type equations in Microsoft Office Word and PowerPoint. Word 97–2003 and Word 2007, 2010 have different methods for you to type an equation.

To type an equation such as $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ in Microsoft Office Word 97–2003:

1. Select the Insert tab and then select Object in the Text group. Click the dropdown box and select Object… to bring up the Object dialog box (Figure 15.1).
2. Look for Microsoft Equation Editor 3.0 under the Create New tab. Select it by clicking it and click the OK button (Figure 15.1). This will bring up the Equation toolbar (Figure 15.2) and an equation text box on your Word document for you to start typing the equation.
3. Type $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ as per normal except that for the math symbols, you type by clicking on the appropriate symbol in the Equation tool.
4. Click outside the equation text box when you are done.

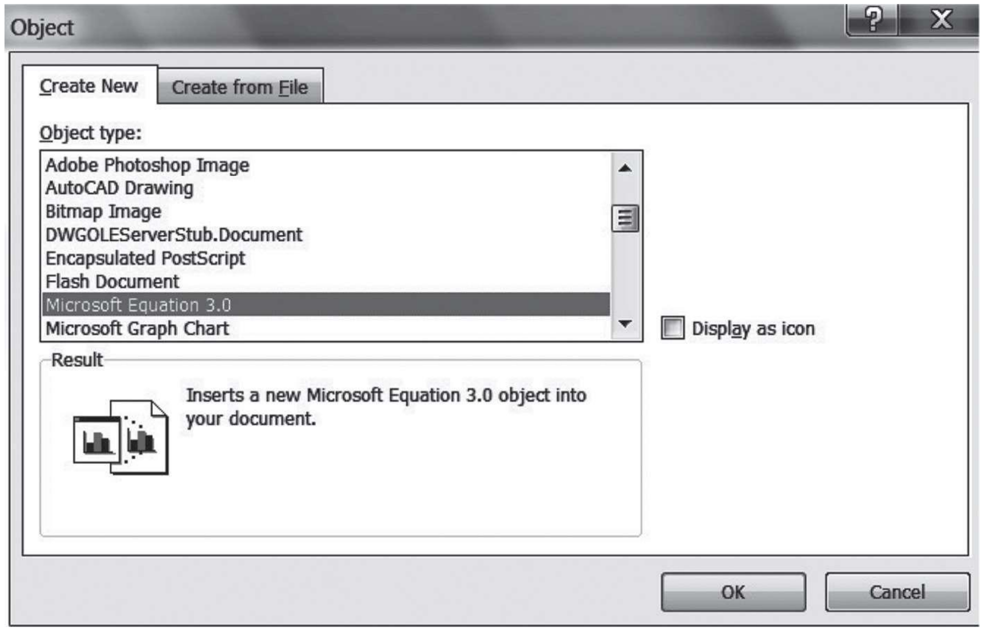

Figure 15.1 Object dialog box under *Insert, Text group, Object* of Microsoft Office Word 97–2003.

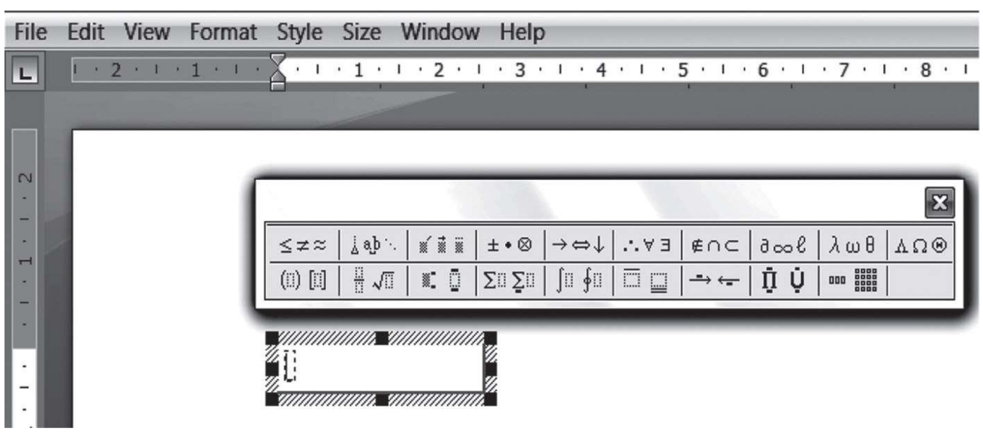

Figure 15.2 Microsoft Equation 3.0 toolbar and equation text box in Microsoft Office Word 97–2003.

Microsoft Office 2007 and 2010 provide a more user-friendly equation tool for you to type equations. The Microsoft Equation 3.0 editor in Word 97–2003 is an add-in which may still be available in your version of Word 2007 or 2010 if you had installed it. To type $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ by using the newer Equation editor in Word 2007 and 2010:

1. Select the Insert tab and you will see a Symbols group as shown in Figure 15.3.
2. Select the Equation dropdown box and you will see groups of Built-In equations.

3. Select the available Built-in quadratic equation $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ as shown in Figure 15.4 and you are done.

If you are typing other forms of equations, you can either select a Built-In equation that is close to the form of your equation and modify it by selecting the appropriate math symbol in the Equation Design menu bar as shown in Figure 15.4, or you can select Insert New Equation and type in the equation in the Equation text box.

A word of caution: If you save a Word 2007 or 2010 document in the earlier version Word 97–2003, the equation will be saved as an image and you cannot edit the equation anymore. Similarly if you open a Word 97–2003 document in Word 2007 or 2010, you can only edit the equation if the Microsoft Equation 3.0 add-in has been installed.

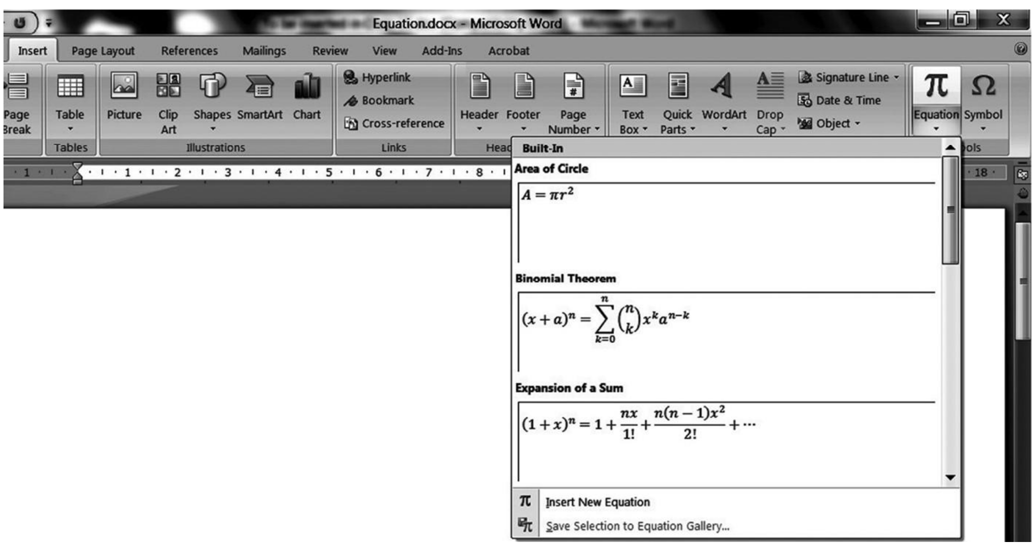

Figure 15.3 Equation dropdown menu in the *Symbols* group of Microsoft Office Word 2007.

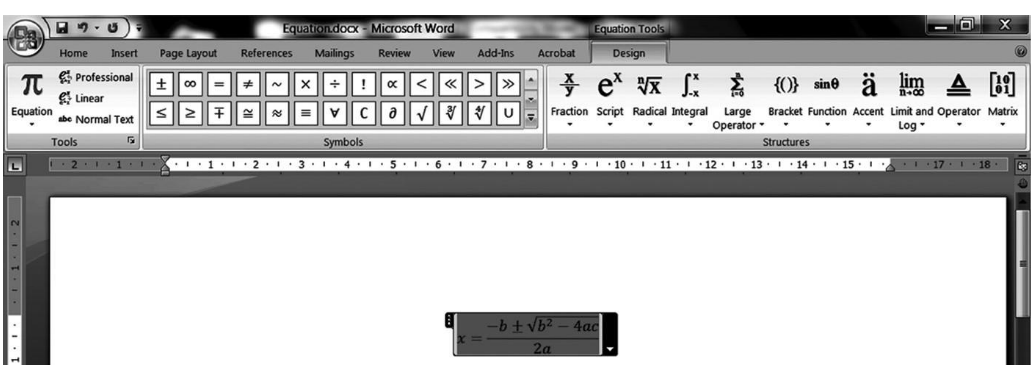

Figure 15.4 Equation Design menu in Microsoft Office Word 2007, 2010.

CHECKLIST FOR RESULTS AND DISCUSSION

Does your results and discussion include

- ☐ Presentation of results that are related to your research questions/hypotheses?
- ☐ Technical or mathematical explanation of your findings (without argument for causality)?
- ☐ References to methodological and background information?
- ☐ Explanation (or argument for causality) or comparison with prior findings, or evaluation of your findings in light of theories?

INTERESTING FACTS

Richard Feynman, the renowned theoretical physicist in path integral formulation of quantum mechanics and Nobel laureate, completed his PhD thesis at Princeton University in 1942 titled 'The Principle of Least Action in Quantum Mechanics'. His thesis laid the groundwork of path integral technique and Feynman diagrams.

REFERENCES

Gray, B., & Biber, D. (2012). Current conceptions of stance. In K. Hyland & C. S. Guinda (Eds.), *Stance and Voice in Written Academic Genres*. Basingstoke: Palgrave Macmillan.

Peacock, M. (2002). Communicative moves in the discussion section of research articles. *System* 30: 479–497.

Swales, J. (1990). *Genre Analysis: English in Academic and Research Settings*. Cambridge: Cambridge University Press.

Swales, J., & Feak, C. (2012). *Academic Writing for Graduate Students* (3rd ed.). Ann Arbor: University of Michigan Press.

Thompson, G., & Hunston, S. (2000). Evaluation: An introduction. In S. Hunston & G. Thompson (Eds.). *Evaluation in Text*. Oxford: Oxford University Press.

Wijaya, M., & Leong, E. C. (2014). Modelling shrinkage behaviour of soft soils. In *Proceedings of Soft Soils*, Bandung, Indonesia, 20–23 October 2014, Vol. 2, pp. C6.1–C6.6.